Validation of CERES-derived MODIS Cloud Properties Using the ARM SGP data

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What's new ?

(1) This is Edition 2 results, for low-level clouds (height <2.4 km), using a lapse-rate method, NOT ECMWF sounding.

(2) Using ARM sounding for wind strip correction, NOT ECMWF sounding

(3) Using 10-km wide for wind strip, NOT 3-km.

(4) The new MODIS results include different LWP/IWP and t for water and ice clouds in mixed-phase clouds, respectively.

(5) All cases in height/temp and microphysics are single-layer and overcast clouds.

Data Source and Average Methods

There are 3 data sets in the comparison

Surface:

DOE ARM measurements and retrievals averaged over a 1-hour interval centered at the time of the satellite overpass.

Satellite: Two approaches

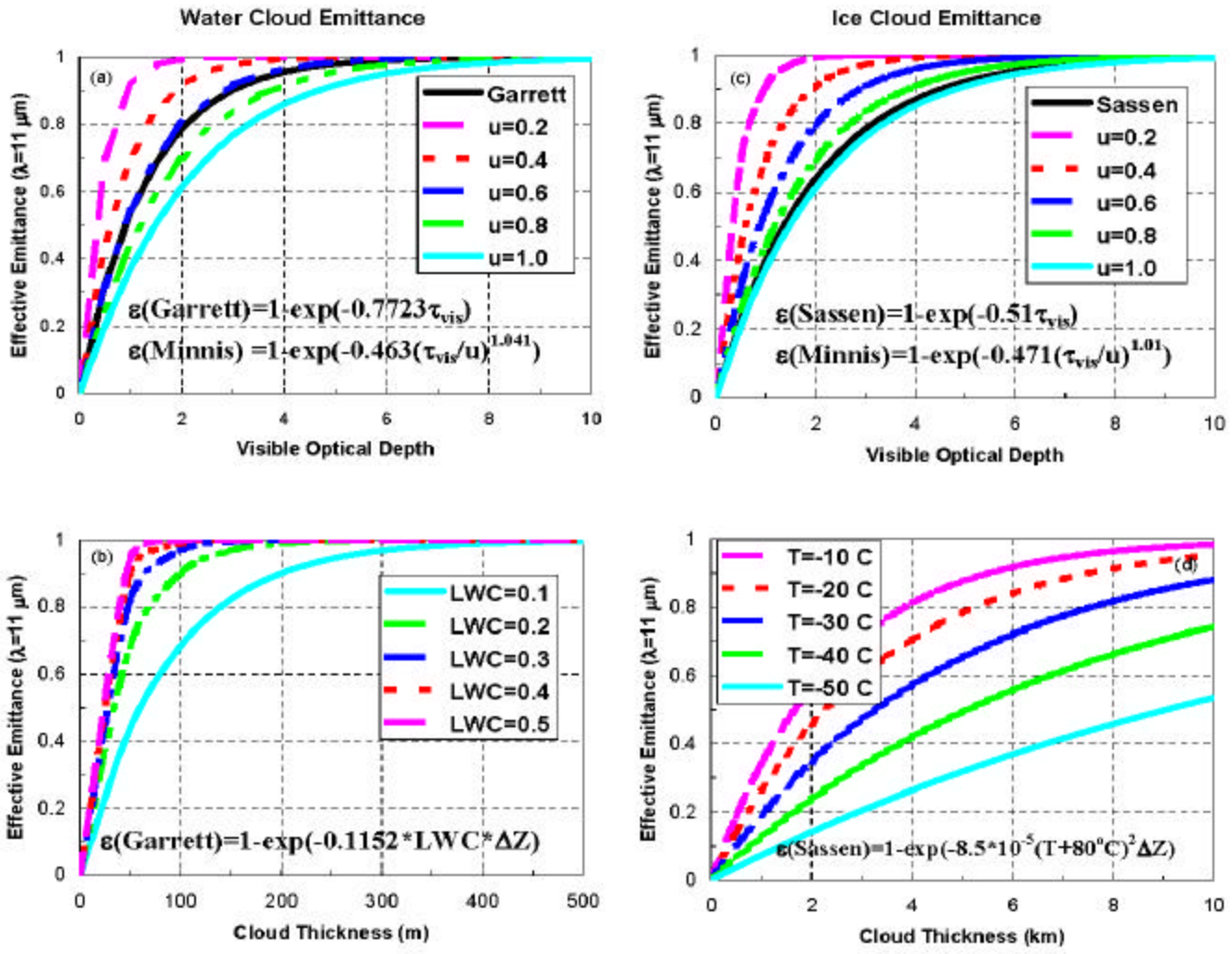
Simpler: **Average all pixels within a 30-km x 30-km area centered on the ARM SGP site**

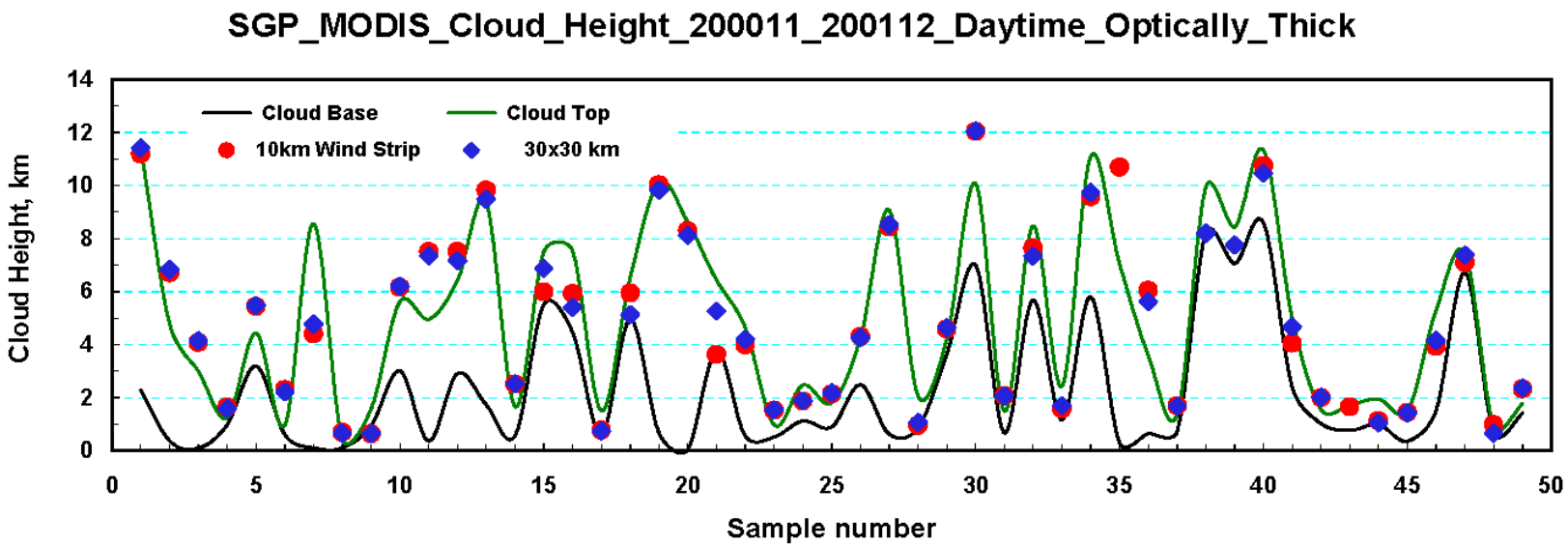
Complex:

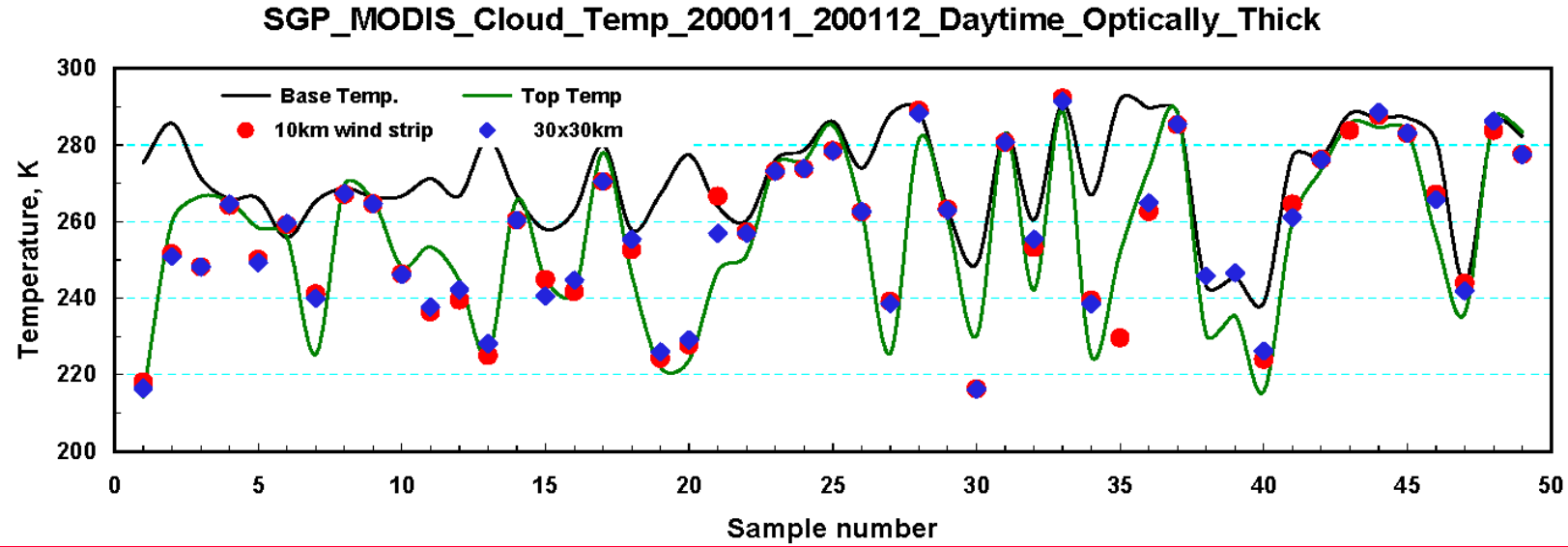
Step 1: Parallax correction for off-nadir satellite views using surface-radar derived cloud top height and satellite VZA

Step 2: Cloud advection during ±30 min of satellite overpass the SGP with a 10-km wide strip using ARM sounding provided wind speed and direction.

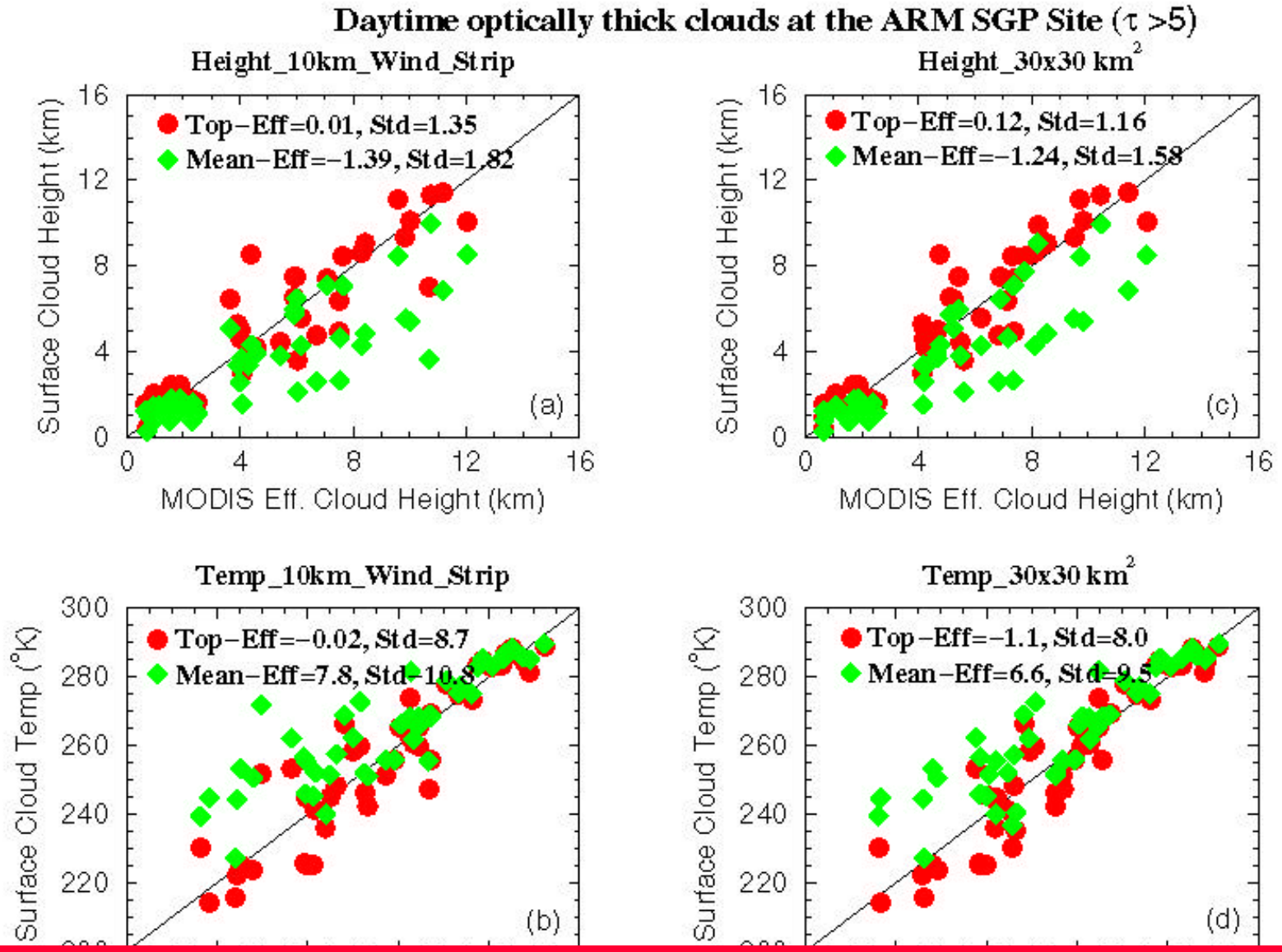
What do we expect for cloud height/temp comparison from theoretical study ?



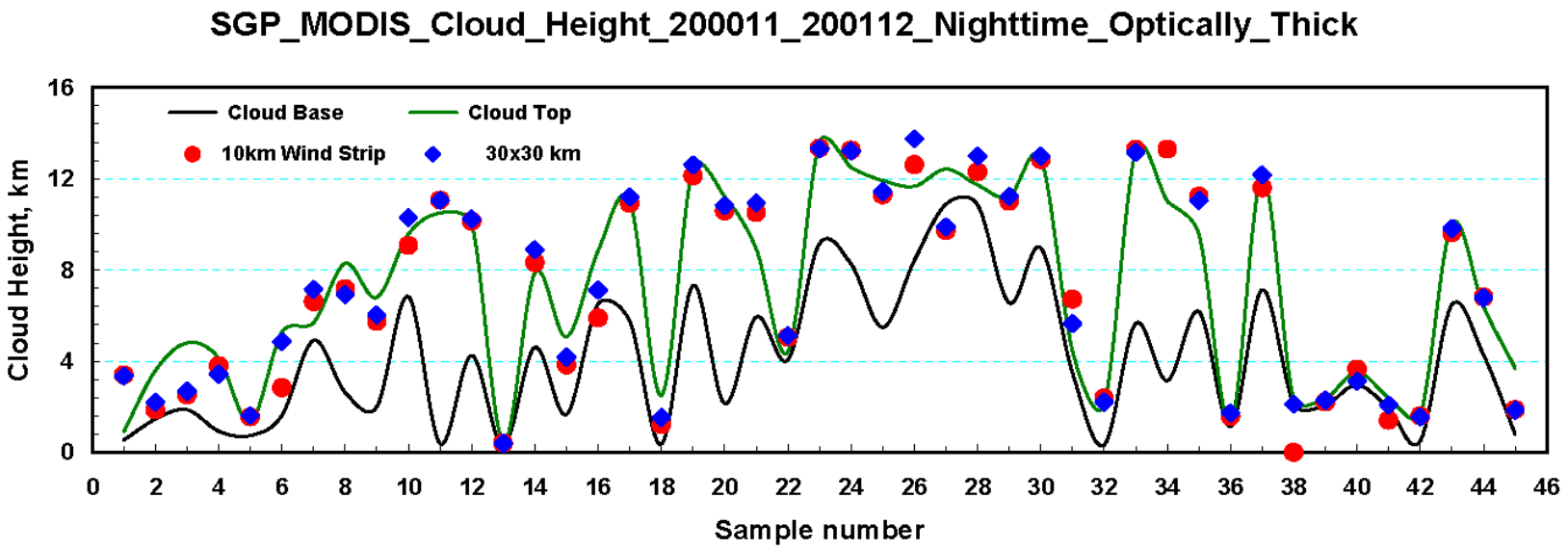


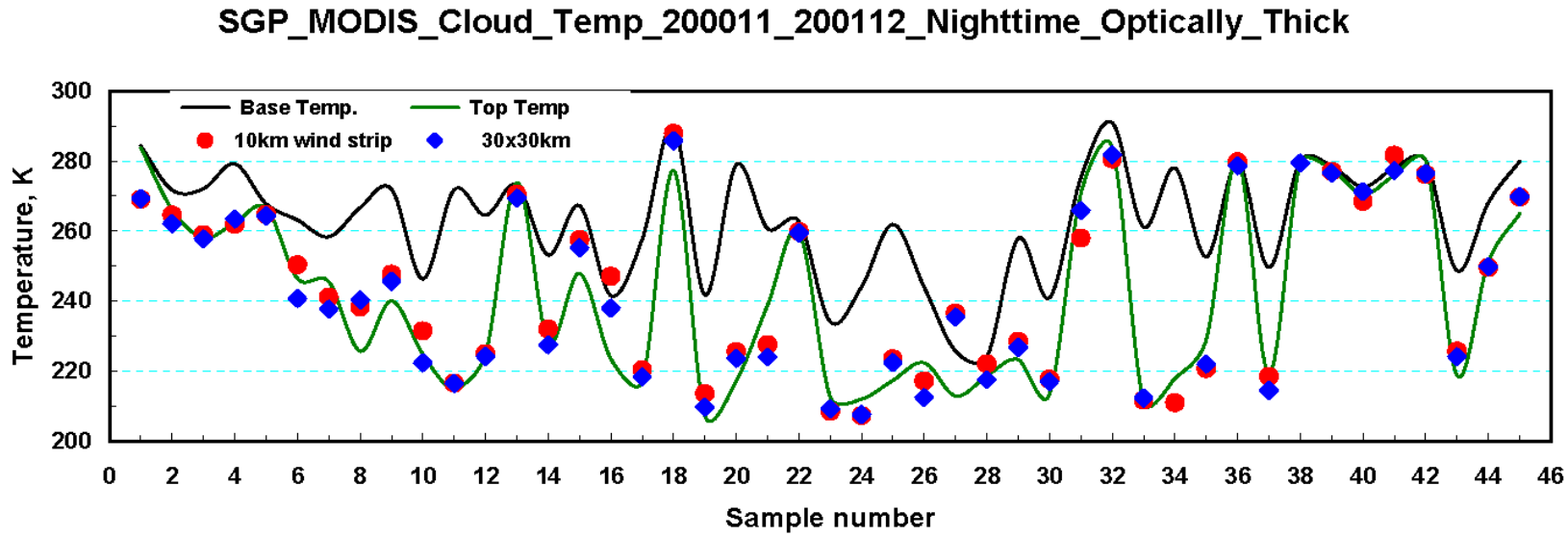


Most MODIS heights are near surface cloud top

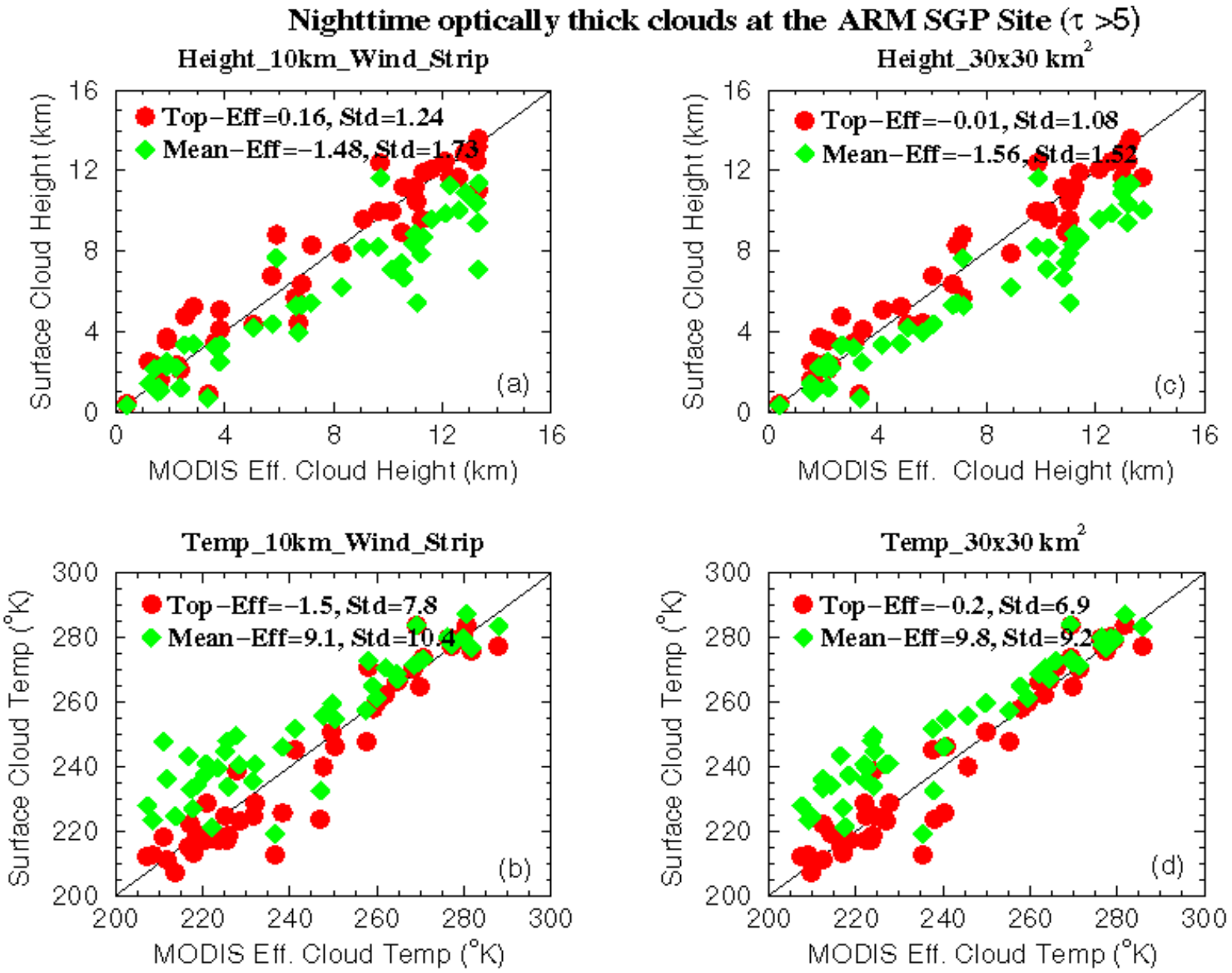


The lapse-rate results are much better than ECMWF sounding for low-level clouds



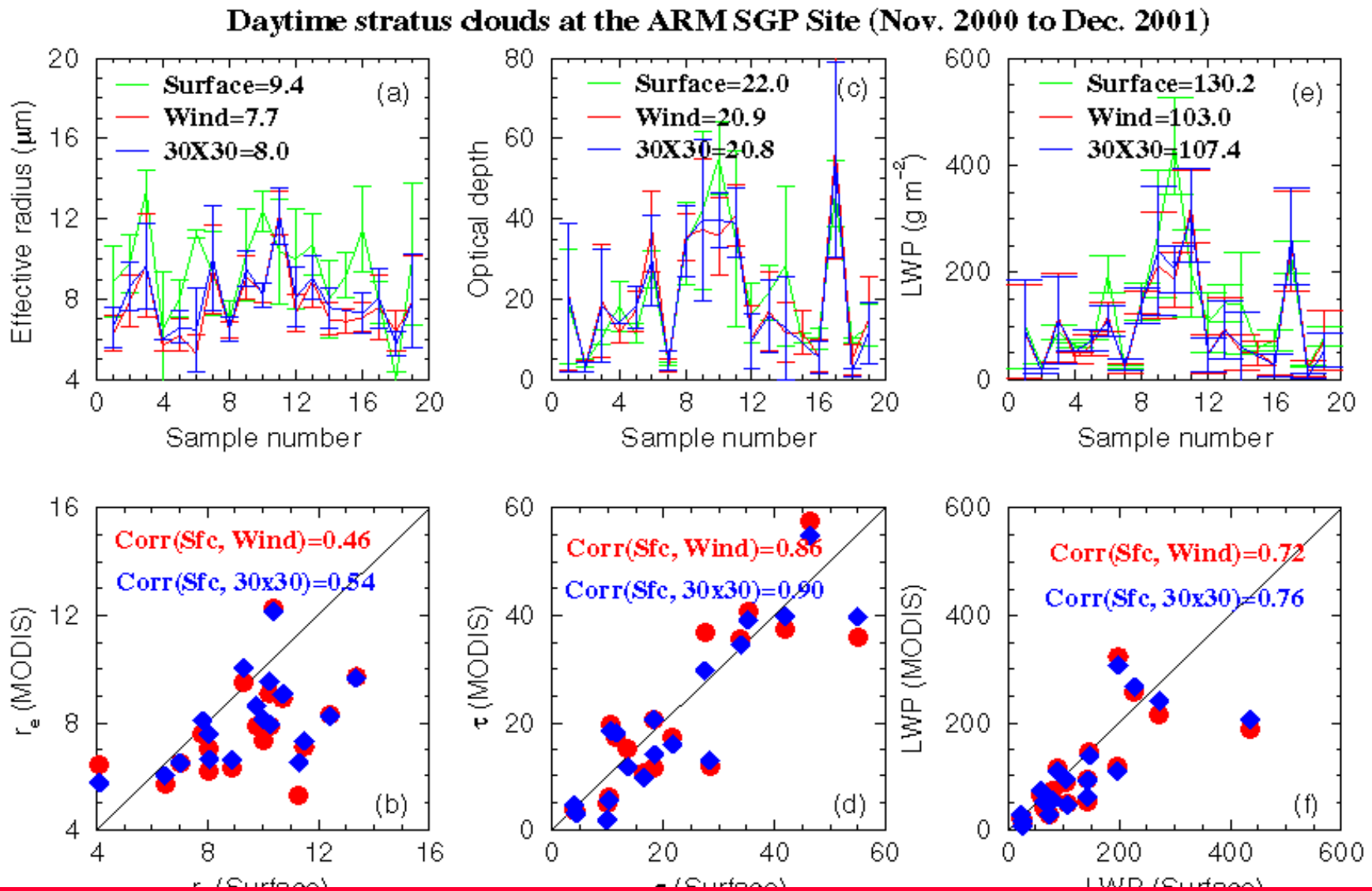


Same as daytime comparison, excellent agreement

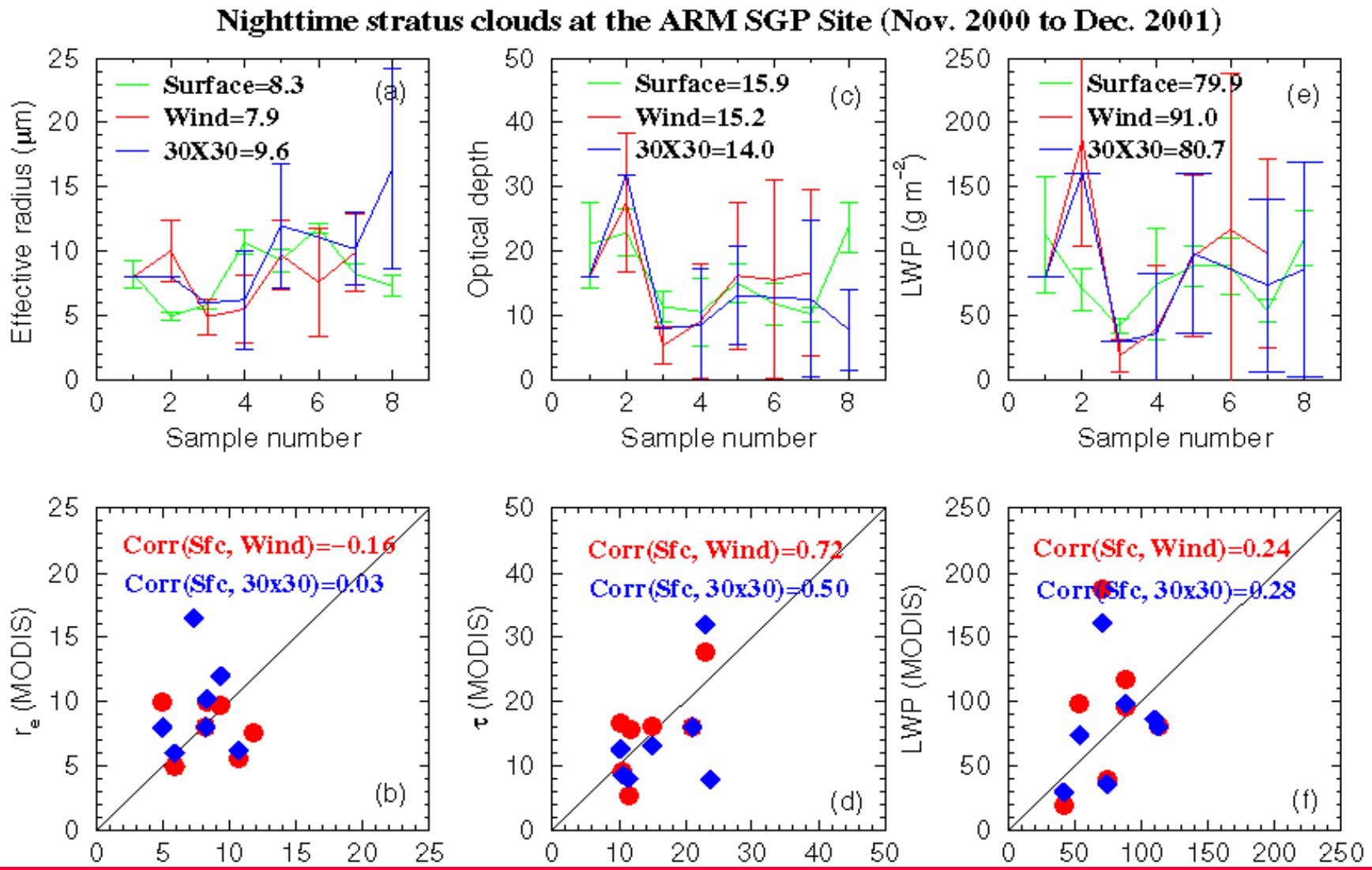

Nighttime optically thick clouds at the ARM SGP Site (τ >5)
Height_10km_Wind_Strip
Top−Eff=0.16, Std=1.24
Mean−Eff=−1.48, Std=1.73
(a)
Surface Cloud Height (km)
MODIS Eff. Cloud Height (km)
Height_30x30 km2
Top−Eff=−0.01, Std=1.08
Mean−Eff=−1.56, Std=1.52
(c)
Surface Cloud Height (km)
MODIS Eff. Cloud Height (km)
Temp_10km_Wind_Strip
Top−Eff=−1.5, Std=7.8
Mean−Eff=9.1, Std=10.4
(b)
Surface Cloud Temp (°K)
MODIS Eff. Cloud Temp (°K)
Temp_30x30 km2
Top−Eff=−0.2, Std=6.9
Mean−Eff=9.8, Std=9.2
(d)
Surface Cloud Temp (°K)
MODIS Eff. Cloud Temp (°K)

Conclusion for optically thick cloud height and temp comparison

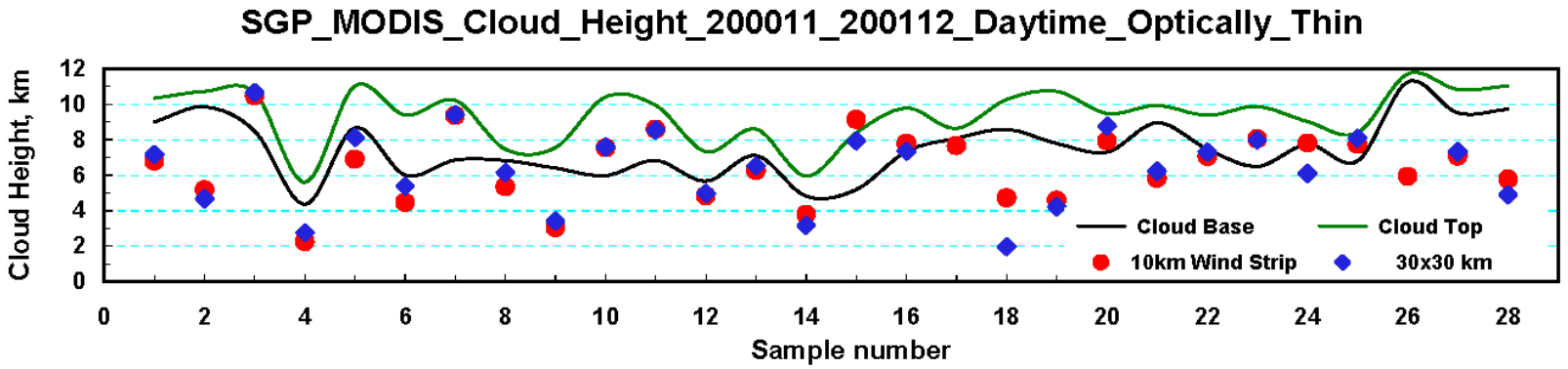
- **Both day and night MODIS cloud height and temp agree very well with surface measurements**
- **The excellent agreements in cloud height and temp comparison also suggest we should have a good agreement in cloud optical depth comparison.**

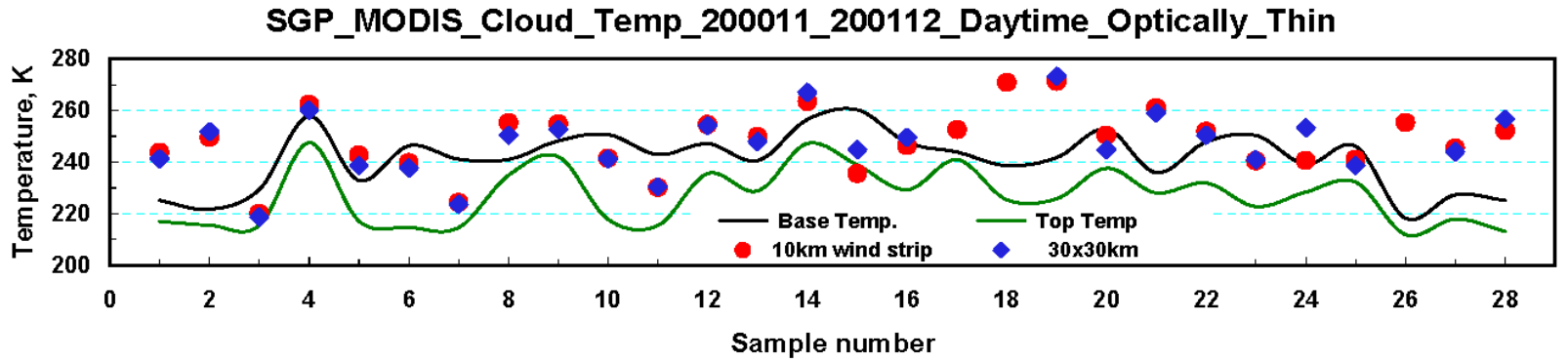


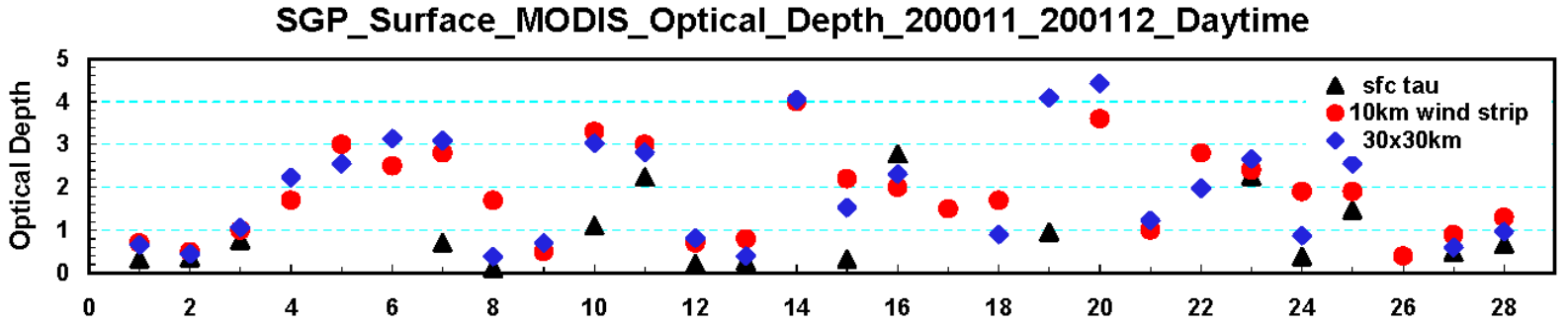
MODIS τ agree to surface in 5%, r_e and *LWP* are 20% lower than surface. New wind strip results have larger correlations than old



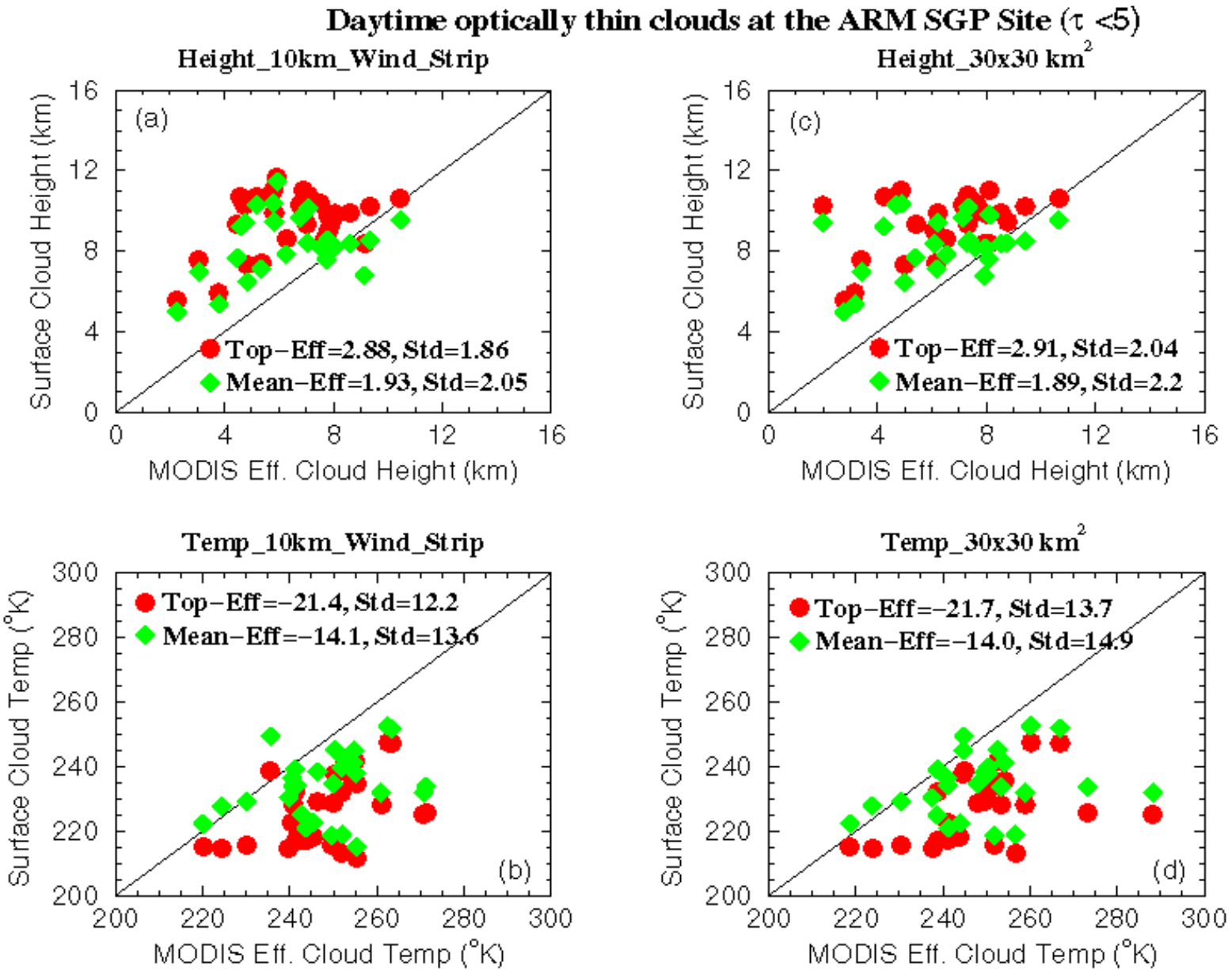
New wind strip results have much higher correlations than old results

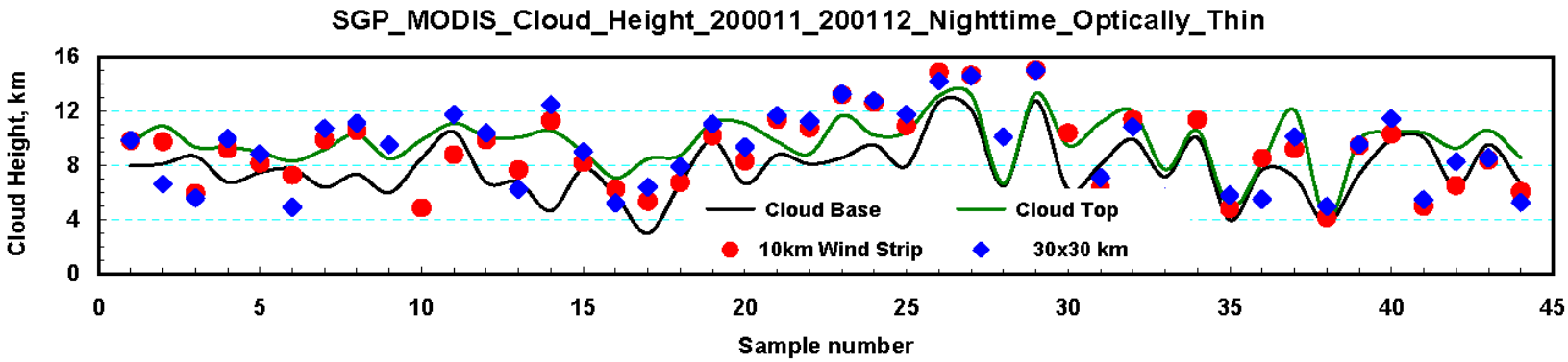


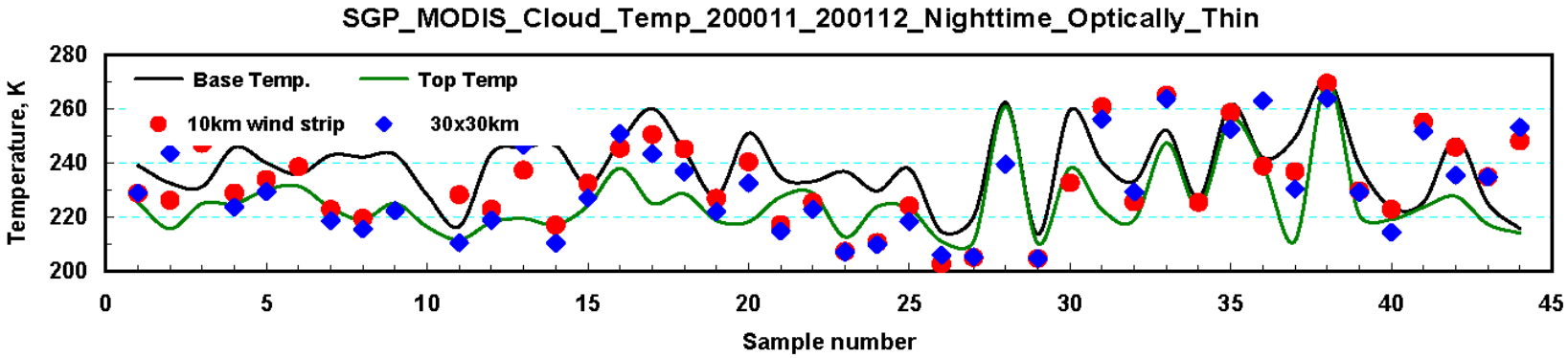


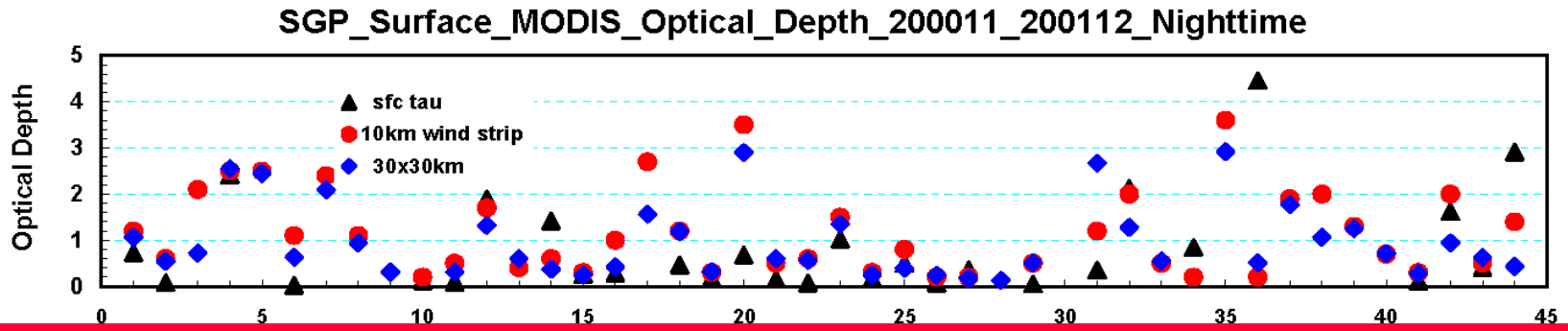


More than half of MODIS height (temp) are lower (higher) than surface base height (temp) due to overestimated MODIS cirrus t

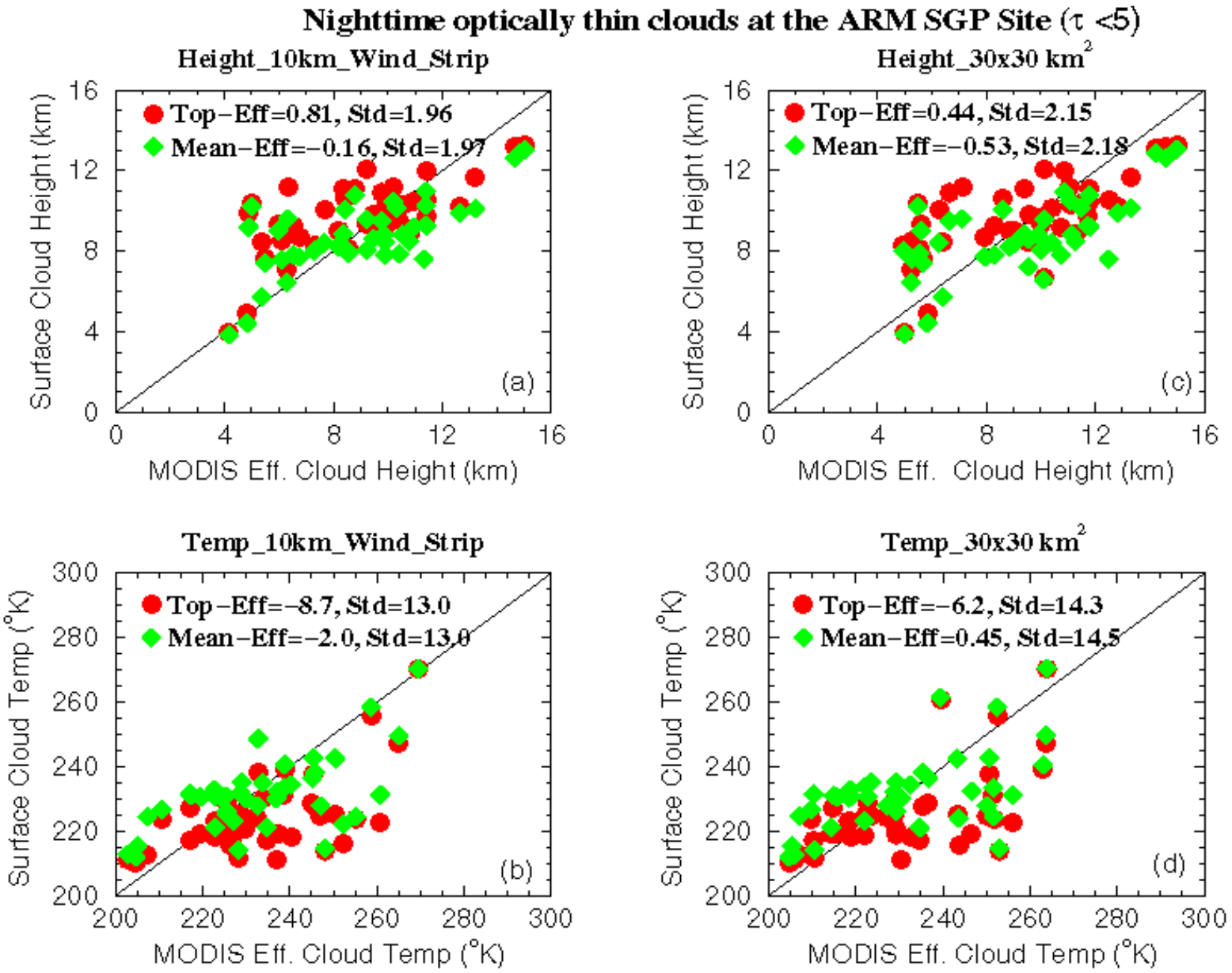

Daytime optically thin clouds at the ARM SGP Site (τ <5)
Height_10km_Wind_Strip
(a)
Surface Cloud Height (km)
MODIS Eff. Cloud Height (km)
Top−Eff=2.88, Std=1.86
Mean−Eff=1.93, Std=2.05
Height_30x30 km2
(c)
Top−Eff=2.91, Std=2.04
Mean−Eff=1.89, Std=2.2
Temp_10km_Wind_Strip
(b)
Surface Cloud Temp (°K)
MODIS Eff. Cloud Temp (°K)
Top−Eff=−21.4, Std=12.2
Mean−Eff=−14.1, Std=13.6
Temp_30x30 km2
(d)
Top−Eff=−21.7, Std=13.7
Mean−Eff=−14.0, Std=14.9

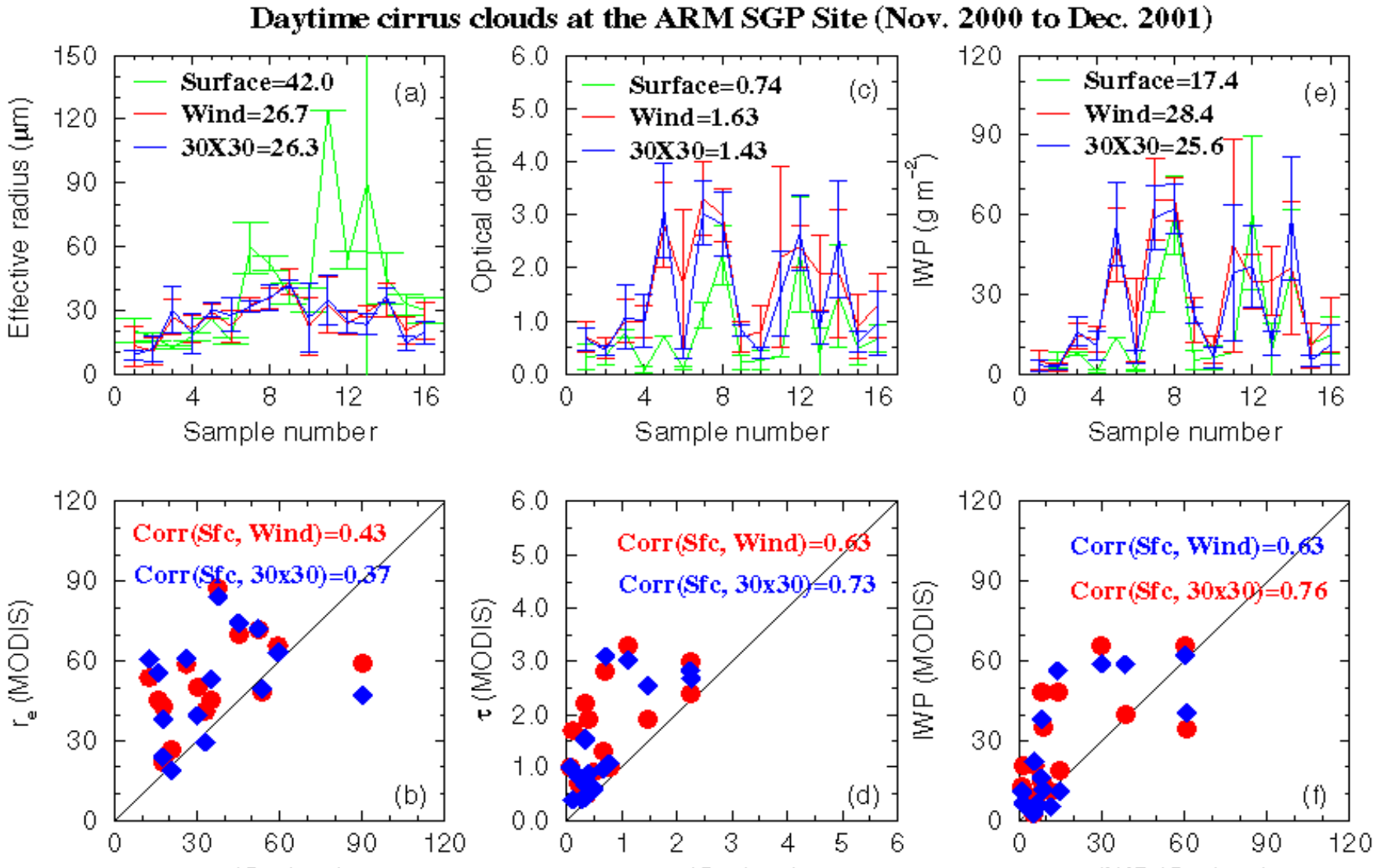




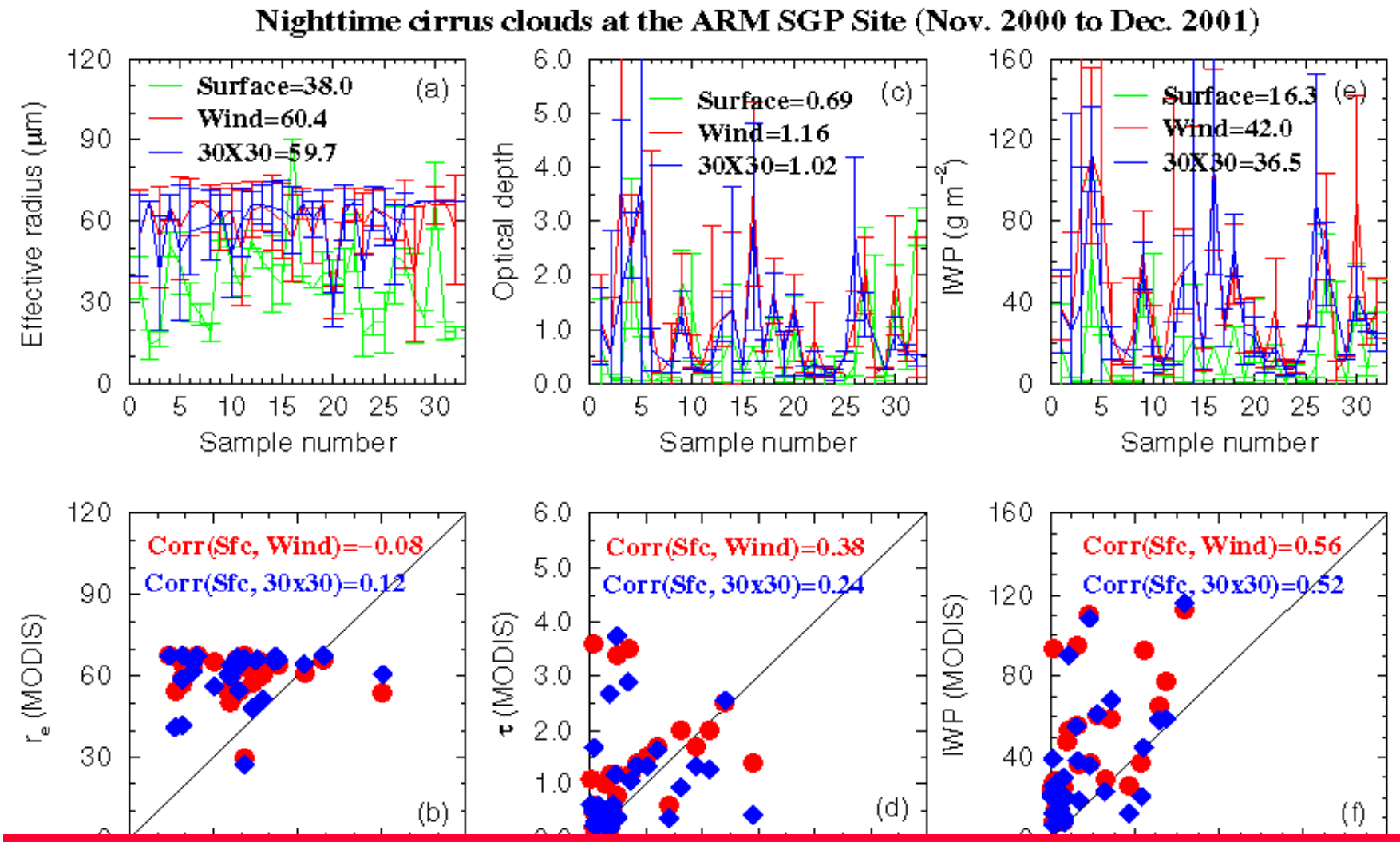


Some of MODIS height are higher than surface cloud top, which are NOT due to overestimated t and cannot explain


Nighttime optically thin clouds at the ARM SGP Site (τ <5)
Height_10km_Wind_Strip
Top−Eff=0.81, Std=1.96
Mean−Eff=−0.16, Std=1.97
Surface Cloud Height (km)
MODIS Eff. Cloud Height (km)
(a)
Height_30x30 km2
Top−Eff=0.44, Std=2.15
Mean−Eff=−0.53, Std=2.18
(c)
Temp_10km_Wind_Strip
Top−Eff=−8.7, Std=13.0
Mean−Eff=−2.0, Std=13.0
Surface Cloud Temp (°K)
MODIS Eff. Cloud Temp (°K)
(b)
Temp_30x30 km2
Top−Eff=−6.2, Std=14.3
Mean−Eff=0.45, Std=14.5
(d)



MODIS r_e are 36% smaller, t is 120% and IWP is 60% larger than Surface. New wind strip results have higher correlations than old.



MODIS r_e are doubled than its daytime counterpart, while surface r_e are consistent. An internal check for MODIS day/night retrieval algorithms are necessary.

Summary

Excellent:

MODIS derived both day and night optically thick cloud height and temp, as well as optical depth.

Good: Need a slight effort in improvement

MODIS stratus r_e and *LWP* are about 20% lower than surface retrievals.

Fair: Need some effort in improvement

MODIS cirrus r_e/t/IWP have some improvement, but not enough, need more.

Poor: Need significant improvement

Both day and night MODIS optically thin cloud height and temp


Thanks for your attention!
CLIFFORD